A Re-Examination of the Argument Against Problem-Based Learning in the Classroom

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Abstract

The primary purpose of this study is to examine Kirschner, Sweller, and Clark's (2006) argument against problem-based learning (PBL) by analyzing research used to support their stance. The secondary purpose is to develop a definition of PBL that helps practitioners use this technique. Seven studies were analyzed to determine whether the PBL instruction included three key components: an appropriate level of guidance, a well-constructed problem, and an appropriate amount of debate and discussion. Upon analysis, these articles do not support Kirschner et al.'s claim. Results also showed that all of the three key components are necessary for quality PBL instruction.

Problem-based learning (PBL) has become more popular in recent years, but the usefulness and effectiveness of this instructional technique is still being determined. Research on PBL has resulted in mixed findings in that some researchers have reported successful learning through PBL (Hardiman, Pollatsek, & Well, 1986; Moreno, 2004; Samuelsson, 2008; Schauble, 1990; Warren, Dondlinger, & Barab, 2008), whereas others have reported the superiority of traditional teaching methods (Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Klahr & Nigam, 2004; Kirschner, Sweller, & Clark, 2006; Tuovinen & Sweller, 1999).

Through the use of a content analysis, Kirschner et al. (2006) presented an argument against PBL titled, "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching." The researchers cited seven articles as empirical evidence to support their claim that PBL does not work. To examine the strength of this argument, it is first necessary to determine whether or not these sources are accurate representations of quality PBL instruction. This is problematic in that learning theorists are still in the process of defining what is necessary for the successful use of this technique. For this reason, the first goal of this paper is to examine the argument against the use of PBL techniques made by Kirschner et al. (2006) and the research they used to support this argument. The second goal of this paper is to use this content analysis to work toward a definition of PBL that is more descriptive in terms of appropriate and effective use of this technique.

The Argument for Problem-Based Learning

Problem-based learning has evolved from constructivist theory, and its proponents argue that it is more likely than traditional teaching methods to involve the learner and lead to deeper levels of understanding (Hmelo-Silver et al., 2007). Whereas traditional methods of teaching (e.g., lecture) encourage learner passivity, PBL requires learner engagement in the learning event. PBL involves the use of self-directed learning, as well as the development of critical thinking and problem-solving skills (Mauffette, Kandlbinder, & Soucisse, 2004). The underlying rationale of PBL is that "students take greater responsibility for their own learning, with the

benefit that they develop a wider range of transferable skills such as communication skills, teamwork and problem-solving" (Mauffette et al., 2004, p. 11).

Slavkin (2004) stated that PBL has four basic goals. The first is the redefinition of the role of teachers from transmitters of knowledge to facilitators or guides. The second goal is that students develop an awareness of their own role within the classroom and begin to examine that role, moving from a passive approach to learning to a more active one. Third, PBL involves more formative evaluation of student learning, because it involves constant feedback between the facilitator and the learner. This is contrary to traditional teaching methods, which often involve a summative approach to evaluation. Fourth, PBL redefines the roles of parents and community, as they begin to serve as resources for the learner. In this way, the parents and community are also moved toward a more active role in the learning of the student. These four goals align with constructivist theory in that they encourage the engagement of the learner in constructing knowledge in a way that is personally relevant and is influenced by the learner's community.

In addition to developing valuable critical thinking and teamwork skills, it has been suggested that students of PBL also perform equally as well as, or better than, students who have received traditional instruction on examinations and report higher levels of satisfaction, (Mauffette et al., 2004). Samuelsson (2008) reported that, when compared to traditional teaching methods, there was no significant difference in achievement scores between PBL and traditional techniques. However, PBL did prove to be more effective in motivating learners (Samuelsson, 2008). In a study comparing students in a PBL and traditional physics class, Bowe and Cowan (2008) found that students in a PBL physics class were more actively engaged than their counterparts and developed group work skills throughout the course. They also reported that students in the PBL course scored significantly higher on the end-of-term exam than their counterparts in the traditional physics class. Although such findings argue persuasively for the use of PBL, there is still debate about its effectiveness.

The Argument against Problem-Based Learning

Opponents of PBL argue that this technique is less effective and less efficient than traditional teaching methods using heavy guidance (Kirschner et al., 2006) and there is research to support this claim (Kalyuga et al., 2001; Klahr & Nigam, 2004; Tuovinen & Sweller, 1999). According to Kirschner et al. (2006), proponents of PBL ignore the issue of cognitive overload; for this reason, PBL is likely to be ineffective, especially with novice learners, because the learners' working memory will be overwhelmed (Kirschner et al., 2006, p. 77). PBL is also argued to be an unrealistic enterprise in the classroom, because of the extra time required to allow learners to construct knowledge on their own instead of through direct transmission (p. 75). Kirschner et al. cited several sources to support their claims: Klahr and Nigam (2004) found that students who were taught with traditional techniques out-performed students taught using PBL instruction. They also found that students of traditional techniques were more likely to retain their new knowledge. When Tuovinen and Sweller (1999) investigated cognitive load and PBL, they documented that the PBL learners' working memories were overwhelmed. Altogether, Kirschner et al. cited seven articles to support their argument that PBL has been proven ineffective.

Concerns about the Kirschner et al. Argument

Although the use of cognitive load theory and the presentation of such research make the Kirschner et al. argument strong, there are two important weaknesses within their argument: their definition of PBL and the nature of the PBL used within these supportive studies. With regards to definition, Kirschner et al. make the mistake of grouping inquiry learning and PBL together with a method called "pure discovery," (Hmelo-Silver, et al., 2007). Pure discovery involves presenting the learners with a problem that they must engage with, and then offering minimal to no instructional guidance throughout the learning process. Hmelo-Silver et al. (2007) argue that this is a misrepresentation of PBL, which actually involves a great deal of scaffolding and guidance on the part of the teacher (p. 99). According to Abrams et al. (2008) this is a common misconception of PBL which they sought to address, explaining "We would expect the nature of the support that is needed in inquiry activities will vary as the level of the inquiry is shifted" (p. xxxiv). In other words, in PBL, support is needed at varying levels depending upon contextual factors. This differentiates PBL from pure discovery learning.

Hmelo-Silver et al. (2007) have already sufficiently addressed Kirschner et al.'s problematic definitions, and have offered their own research supporting the use of PBL. They addressed the theoretical soundness of PBL and provided examples of its successful application in a classroom context. As the issue of definition has already been debated, this is not the purpose of this paper. The aim of this paper is to take the analysis one step further, and examine the sources used by Kirschner et al. to buttress their argument. The underlying idea is to determine whether the studies used a definition of PBL that is in line with Kirschner et al. or Hmelo-Silver et al.

A Definition of Problem-Based Learning

Despite the continued use of PBL in classrooms and the evidence of its effectiveness, a common definition of PBL has not been realized. There are many definitions of PBL, and they do not all agree. PBL has also been referred to as inquiry learning or problem-based instruction. For the purposes of this paper, these techniques will be referred to as PBL. Establishing PBL as common practice in classrooms without a concrete definition is problematic, as it leaves teachers with little guidance on how to use PBL effectively and appropriately (Abrams et al., 2008). Through a review of the literature, I found numerous definitions. Savin-Baden (2004) defines PBL as:

> an approach to learning that is characterized by flexibility and diversity in the sense that it can be implemented in a variety of ways in and across different subjects and disciplines in diverse contexts. As such it can therefore look very different to different people at different moments in time depending on the staff and students involved in the programmes utilizing it. However what will be similar will be the focus of learning around problem scenarios rather than discrete subjects. (p. 3)

This is a more general way to define PBL and its over-arching goals. Although this is useful when discussing PBL and its groundings in learning theory, it is not as useful to teachers and instructors who are attempting to use PBL in a classroom setting. According to Hmelo-Silver et al. (2007), "In PBL, students learn content, strategies, and self-directed learning skills through

collaboratively solving problems, reflecting on their experiences, and engaging in self-directed inquiry" (p. 100). Slavkin (2004) defined PBL as involving a problem, wherein, "Students explore the problem and also investigate the strategies necessary to resolve the issue, strengthening their problem-solving skills, inductive reasoning skills, and creativity" (p. 77). These definitions of PBL express the centrality of the problem in PBL and the goals that PBL is meant to achieve, but if PBL is meant to be useful in practice, a more detailed definition is required. Synthesizing Abrams et al.'s (2007) discussion of crucial components of PBL and Mauffette et al.'s (2004) discussion of the quality of problems in PBL, three necessary components of PBL are identified: (a) an appropriate amount of debate and discussion is used, (b) a well-constructed problem is used, and (c) an appropriate level of guidance is used.

Level of guidance refers to the amount of scaffolding and instruction that is provided throughout the learning exercise by the teacher/facilitator. A well-constructed problem is clearly stated, developmentally appropriate, and identifies the goal the learner must obtain or the action the learner must demonstrate. In PBL, it is also crucial that learners be required to formulate explanations, and then communicate and justify those explanations through the use of debate and discussion. This is one aspect of PBL that is often overlooked, even though it is just as important as the activity itself (Yore, Henriques, Crawford, Smith, Gomez-Zweip, & Tillotson, 2008, p. 48).

Purpose

The aim of this study is to add to the PBL body of knowledge by examining the argument against PBL through a content analysis of seven research articles cited by Kirschner et al. (2006) to support their stance. This content analysis will assess the PBL instruction used within these studies for three factors: level of guidance, quality of the problem, and the presence of debate and discussion. The sample used for this study was taken directly from the reference list of Kirschner et al. (2006) and was cited in direct relation to the statement that PBL is an inefficient and ineffective method.

The following research questions will guide this analysis:

1. What articles from the sample report successful outcomes using PBL instruction?
2. What articles from the sample use an appropriate level of guidance?
3. What articles from the sample use well-constructed problems to drive the instruction?
4. What articles from the sample use debate and discussion as an integral part of the learning activity?

Method

The Instrument

The instrument I compiled for this analysis had four components from two sources, (i.e., Abrams et al., 2008; Mauffette et al., 2004). First, it was necessary to determine whether or not the article reported a successful outcome. I considered articles to have reported successful outcomes if they self-identified as having successful outcomes using the PBL instruction as I have defined

it in this paper: a learning event that presents a well-constructed problem with which the learners must actively engage, and that uses appropriate levels of guidance, debate, and discussion.

For the second component, it was necessary to identify whether or not PBL in the research had used an appropriate level of guidance. Abrams et al. (2008) provided Schwab's (1962) *Levels of Inquiry* as a "way to understand the various ways in which inquiry can be enacted in the classroom" (p. xx; see Table 1). Schwab's *Levels of Inquiry* identifies four levels of guidance in an inquiry situation. First is Level 0, in which the question, the data collection methods, and the interpretation of the results are provided by the instructor. This aligns with more traditional methods of teaching. In level 1 inquiry, more responsibility is given to the learner, in that the interpretation of the results is provided by the student using evidence collected as directed by the instructor (Abrams et al., 2008, p. xx). In level 2 inquiry, the question is provided by the instructor, but the data collection methods and the interpretation of results is the responsibility of the learner. Level 1 is appropriate for novice learners being introduced to a new body of knowledge or skill, whereas level 2 is more appropriate for learners with some experience with the material. Finally, level 3 inquiry places the responsibility of identifying the question, choosing data collection methods, and interpreting the results in the hands of the learners (Abrams et al., 2008, p. xx). According to Abrams et al., an example of level 3 inquiry would be a students' science fair. This construct was used to determine the level of guidance provided in the PBL within the research articles and whether or not it this level was suitable.

For the third component of the analysis instrument, the quality of the problems used in the PBL instruction needed to be judged. Mauffette et al.'s (2004) *Criteria for Motivational Problems* was used to evaluate the problems driving the PBL instruction (see Table 2). These criteria evaluate seven aspects of PBL problems on three different levels: introductory, intermediate, and advanced. The introductory criteria were used for PBL where learners were described as novices or having no prior experience with the material. The intermediate criteria were to be used for articles where learners were described as having some prior knowledge of the material, and advanced criteria were to be used if learners were described as experts. PBL instruction within the research had to satisfy six of the seven criteria in order to be labeled as having a well-constructed problem.

For the fourth component of the instrument, it was necessary to determine whether the PBL instruction had incorporated the necessary amount of debate and discussion. Abrams et al. (2008) presents the National Science Education Standards' *Essential Features of Classroom Inquiry* as a method for examining how inquiry is enacted in the classroom (p. xiv; see Table 3).

As these five features evaluate how the learner was required to formulate, communicate, and justify explanations, this construct was appropriate for determining whether an appropriate amount of debate and discussion was used within the PBL instruction. PBL instruction had to satisfy all five of the essential features before it was labeled as using an appropriate amount of debate and discussion. The final instrument was comprised of the four following questions:

1. Does this article report successful outcomes?
2. Where does the instruction fall on Schwab's (1962) *Levels of Inquiry* and was this level appropriate?

3. Does the instruction fulfill Mauffette, Kandlbinder & Soucisse's (2004) *Criteria for Motivational Problems* according to the appropriate level (introductory, intermediate and advanced)?
4. Does the instruction fulfill the NSES (2008) *Essential Features of Classroom Inquiry*, demonstrating an appropriate use of debate and discussion within the instruction?

The Sample

Seven articles were chosen from Kirschner et al.'s (2006) article, "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching." These articles were chosen because they were used as examples of unsuccessful outcomes using problem-based learning. This sample is appropriate for this analysis because the purpose of this study is to gain a deeper understanding of the argument against the use of PBL. Kirschner et al's work is meant to serve as a summary of findings supporting this argument, so it was logical to use these articles as the sample for this study.

The Process

The seven articles were analyzed using the developed instrument for the each of the previously defined components: report of successful findings, appropriate level of guidance, use of a well-constructed problem, and appropriate use of debate and discussion. According to discussions by Abrams et al. (2008) and Mauffette et al. (2004) an example of quality problem-based learning instruction should involve, at minimum, all of the last three components of the developed instrument. Studies successfully addressing these last three components were considered examples of quality PBL instruction.

Results

The overall results of this analysis are presented in Table 4.

Research Question 1

The first research question was: What articles from the sample report successful outcomes using PBL instruction? My analysis revealed that three of the seven articles reported successful outcomes using instruction that was identified under the definition of PBL instruction used in this analysis. None of the articles reporting unsuccessful outcomes satisfied the last three components of the instrument. Three of the articles reporting unsuccessful outcomes did not use an appropriate level of guidance, a well-constructed question, or debate and discussion. One of the articles reporting unsuccessful outcomes did use an appropriate level of guidance and a well-constructed problem, but failed to use debate and discussion. Of the articles reporting successful outcomes using PBL instruction, all three satisfied the final three components of the instrument and were considered examples of quality PBL instruction.

Research Question 2

The second research question was: What articles from the sample use an appropriate level of guidance? Four of the seven articles used an appropriate level of guidance. Of the three articles that did not use an appropriate level of guidance, one study involved pure discovery instruction in which learners experienced the instruction "without any instruction on CVS [control of variables strategy] or any feedback from the experimenter" (Klahr & Nigam, 2004, p. 663). In another study, level 2 inquiry was used despite the fact that learners were identified as having no previous exposure to the material: "participants were familiar with simple electrical diagrams (including parallel and serial conditions of elements) and basic algebraic functions, but they had not been exposed to any training materials on relay circuits and PLC programming" (Kalyuga et al., 2001, p. 581). Level 2 inquiry was also used in the third study despite learners have no prior experience with the software used in the instruction: "None of the participants had used the FileMaker Pro database program previously" (Tuovinen & Sweller, 1999, p. 336).

Research Question 3

Research question 3 asked: What articles from the sample use a well-constructed problem to drive the instruction? Four of the seven articles used a well-constructed problem to drive the PBL instruction. One of the articles using a poorly-constructed problem presented the learners with a problem that was unrelated to the final goal of the instruction. In Klahr and Nigam's (2004) study, students were supposed to learn the control-of-variables strategy (CVS) through the instruction. The researchers described the problem presented to the learners as follows: "They were asked to set up four experiments: two to determine the effect of steepness and two to determine the effect of run length on how far a ball rolls" (p. 663). This problem satisfied only one of the seven *Criteria for Motivational Problems* (Mauffette et al., 2004).

In the Kalyuga et al. (2001) study, the problem presented was clearly defined, however no content or self-contained resources were provided despite the fact that learners had no previous exposure to the material. In addition, the problem was presented using specialized vocabulary and incomplete information was given. Three of the seven criteria were satisfied by the problem in this study. In the Tuovinen and Sweller (1999) article, the goal was not clearly defined, no resources were provided, and the problem was not clearly defined. Only four of the seven criteria were satisfied.

Research Question 4

The fourth research question asked: What articles from the sample use debate and discussion as an integral part of the learning activity? Three of the articles in the study used an appropriate amount of debate and discussion. In the Carlson et al. (1992) article, learners were never required to connect their explanations to scientific knowledge or to communicate and justify their explanations. As previously explained, the Klahr and Nigam (2004) article states that learners went "without any instruction on CVS or any feedback from the experimenter" (p. 663). Learners were not asked to communicate their explanations in any form. In the Tuovinen and Sweller (1999) article, the learners were not encouraged to formulate their explanations given the

relevant evidence, they were not encouraged to connect their explanations to scientific knowledge, and they were not asked to communicate or justify their explanations.

Discussion

The primary purpose of my analysis was to investigate Kirschner et al.'s (2006) argument that PBL instruction is ineffective. The secondary purpose was to work toward a definition of PBL that will make it more useful to practitioners. I addressed the secondary purpose through the development of the instrument used in this study, which led to the identification of three essential components of successful PBL instruction within the literature. I addressed my primary goal by using the instrument to assess the studies used by Kirschner et al. to support their claims about the ineffectiveness of PBL.

Kirschner et al.'s argument against PBL cannot support itself using the seven articles chosen for his content analysis. My analysis revealed that three of the articles used to support Kirschner et al's argument actually reported successful outcomes when a more accurate definition of problem-based learning was applied. Articles that applied a "pure discovery" definition to PBL instruction were determined to be poor examples of PBL.

Articles that reported unsuccessful outcomes were determined to be poor examples of PBL, and using a more updated definition, many of the articles reported successful outcomes. For example, in a study done by Moreno (2004), two different forms of instruction were used. One form qualified as an example of effective PBL, while the other form failed to use an appropriate level of guidance or debate/discussion. The instruction that qualified as effective PBL reported successful outcomes. Kirschner et al. (2006) reported that this article had unsuccessful outcomes with PBL because the "pure discovery" instruction was unsuccessful. This supports the idea that there is a place for problem-based learning instruction if it is constructed well and used appropriately.

My analysis also supported the argument for the importance of debate and discussion in PBL. Of the three articles reporting successful outcomes (i.e., Hardiman et al., 1986; Moreno, 2004; Schauble, 1990), all three used debate and discussion within the instruction. In addition, the Carlson et al. (1992) article used an appropriate amount of guidance and a well-constructed problem, but without debate and discussion, this study still reported unsuccessful findings. When applying PBL in practice, debate and discussion should be viewed as an integral part of the instruction, instead of simply as a way to "wrap up."

The importance of a well-constructed question was also revealed. Of the three articles lacking a well constructed question (i.e., Kalyuga et al., 2001; Klahr & Nigam, 2004; Tuovinen & Sweller, 1999), none of them reported successful outcomes. The question aspect of PBL is what engages the learner, activates prior knowledge, communicates what performance is expected, and tells the learner what goal they are working towards. Without a well-constructed problem, students can become frustrated or lose their motivation (Mauffette et al., 2004, p. 12). Without motivation, students will take a more passive approach to their learning, and "research has shown that the quality of learning depends on the approach students take to their studies" (Mauffette et al., 2004, p. 12).

The necessity of an appropriate level of guidance is also evident. The three articles lacking appropriate guidance (i.e., Kalyuga et al., 2001; Klahr & Nigam, 2004; Tuovinen & Sweller, 1999) also reported unsuccessful outcomes. The prior knowledge and experience of the learners must be taken into account in learning situations because it will determine what level of guidance is appropriate. PBL does not indicate a lack of guidance, and level 3 inquiry is not always appropriate (Abrams et al., 2008).

One of the main concerns about the use of PBL raised by Kirschner et al. is that it can lead to cognitive overload for students. I argue that the use of the components of PBL instruction I described in this paper can be used to reduce students' cognitive overload. When students are given an appropriate amount of guidance, are provided with a question that informs them of what they are expected to accomplish, and when debate and discussion is used to scaffold students' understanding, cognitive load may be reduced. Some evidence for this claim is that all the studies in the sample that reported the use of these three components reported successful outcomes.

As addressed by Hmelo-Silver et al. (2007), the major weakness of Kirschner et al.'s argument is related to their definition. There is a lot of research to support the use of PBL in the classroom, and some of it presented by Kirschner et al. Their argument was correct in one respect, that instruction with minimal or no guidance does not work with non-expert learners. This, however, is not problem-based learning, it is just bad pedagogy.

Limitations and Conclusion

The scope of this study was to analyze the sources used by Kirschner et al. (2006) to argue against the use of PBL. When a more accurate and descriptive definition of PBL is applied to these sources, they no longer support Kirschner et al.'s argument. In fact, my analysis revealed that a few of these sources even refute their claim.

The low number of articles analyzed in the present study is a limitation to the generalizability of the findings. An examination of more articles would allow for greater generalizability of my finding that PBL can lead to successful outcomes in the classroom. In addition, much of the research analyzed in this study focuses on novice learners for whom level 1 inquiry is appropriate. Even in studies using college students, the instruction involved material to which the learners had not been previously exposed. Although this sample is limited, there appears to be a gap in the research on how PBL is used effectively with intermediate and advance learners outside the medical field. Research conducted on intermediate and expert learners would fill this gap and add to the body of knowledge on PBL at inquiry levels 2 and 3. Finally, for PBL to be used successfully on a wider scale, it is necessary to define it in such a way that makes it more useful and accessible to teachers and educators. My hope is that the three components of PBL identified in this paper can provide specific guidelines for the use of PBL in the classroom.

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Table 1

Schwab's Levels of Inquiry (from Abrams, Southerland, & Evans, 2008)

	Source of the question	Data collection methods	Interpretation of results
Level 0	Given by teacher	Given by teacher	Given by teacher
Level 1	Given by teacher	Given by teacher	**Open to student**
Level 2	Given by teacher	**Open to student**	**Open to student**
Level 3	**Open to Student**	**Open to student**	**Open to student**

Table 2

Criteria for Motivational Problems (from Mauffette, Kandlbinder, & Soucisse, 2004)

	Introductory	Intermediate	Advanced
Educational goals	Goals are clearly stated relating to specific student actions	Goals are identified and relate to suggested approaches for learning	Goals are not identified in the problem
Background information	Draws on one source of data	Draws on two or more sources of data	Draws on many sources of data from current practice
Setting	Complete information provided without any details omitted	Most information provided with some details omitted	Information provided with key details omitted
Problem	Clearly identifies and summarizes the problem	States the problem and places it in a wider context	Does not clearly state the problem and emphasizes the wider context
Content	The content is sharply focused, supported with a variety of significant details	The content is structured with a clear focus and supported by relevant details	The content covers a number of areas and is supported with a few general examples
Resources	Includes self-contained independent materials like handouts and worksheets	Includes list of bibliographic references	Includes vocabulary and key concepts
Presentation	Tightly written with limited specialist vocabulary	Clearly written with a range of vocabulary used	Fluid writing style using extensive specialized vocabulary

Table 3

The National Science Education Standards' "Essential Features of Classroom Inquiry" (from Abrams, Southerland, & Evans, 2008)

Essential Feature	Variations			
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new question	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials or other source
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to sharpen communication	Learner given steps and procedures for communication

More--------------------Amount of Learner Self-Direction--------------------Less

More-------------Amount of Direction from Teacher or Material------------Less

Table 4

Article Use/Non-use of the Three Necessary Components of PBL

Article	Appropriate level of inquiry	Well-constructed problem	Use of debate and discussion	Report of successful outcomes
Tuovinen & Sweller (1999)	No	No	No	No
Klahr & Nigam (2004)	No	No	No	No
Kalyuga, Chandler, Tuovinen & Sweller (2001)	No	No	No	No
Moreno (2004)	Yes	Yes	Yes	Yes
Hardiman, Pollatsek, & Well (1986)	Yes	Yes	Yes	Yes
Carlson, Lundy, & Schneider (1992)	Yes	Yes	No	No
Schauble (1990)	Yes	Yes	Yes	Yes